

What is claimed is:

1. A method for forming a capacitor in a semiconductor device:

5 forming a lower electrode constituted with a silicon layer on a semiconductor substrate a predetermined process on which a predetermined process has been completed;

forming a uniform silicon oxide layer on the lower electrode by performing an atomic layer deposition (ALD) process;

forming an aluminum oxide (Al_2O_3) film on the silicon oxide layer; and

crystallizing the Al_2O_3 film by carrying out a heat treatment process.

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2. The method as recited in claim 1, wherein the silicon oxide layer is formed by performing an atomic layer deposition (ALD) process.

20 3. The method as recited in claim 1, wherein the silicon oxide layer is formed by using an in-situ method or an ex-situ method.

4. The method as recited in claim 1, wherein a silicon source selected from a group consisting of SiCl_4 , DCS and HCD and a reaction source selected from a group consisting of H_2O , O_3 and H_2O_2 are used to form the silicon

oxide layer during the ALD process.

5 5. The method as recited in claim 4, wherein a pyridine acting as a catalyst is used when the silicon source and the reaction source are supplied during the ALD process.

10 6. The method as recited in claim 4, wherein each of a supply time and a purge time for the silicon source, and the reaction source is less than 10 seconds respectively.

15 7. The method as recited in claim 2, wherein the silicon oxide layer is formed at a low temperature less than about 200 °C.

 8. The method as recited in claim 7, wherein a thickness of the silicon oxide layer is less than about 10 Å.

20 9. The method as recited in claim 1, wherein the Al₂O₃ film is formed by performing an ALD process.

 10. The method as recited in claim 9, wherein Al(CH₃)₃, which is trimethylaluminum (TMA), is used as an aluminum source, and one of H₂O, O₃ and H₂O₂ is used as a reaction source during the ALD process.

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11. The method as recited in claim 10, wherein a plasma is used as an energy source during the ALD process.

12. The method as recited in claim 11, wherein the
5 ALD process is carried out at a room temperature or at a temperature of about 500 °C.

13. The method as recited in claim 9, wherein a
thickness of the Al₂O₃ film is less than about 100 Å.
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14. The method as recited in claim 1, wherein the heat treatment process is carried out at a temperature greater than 600 °C and in an N₂ or O₂ ambient.

15 15. The method as recited in claim 14, wherein the heat treatment process is carried out by using a furnace annealing process or a rapid thermal process (RTP).

16. The method as recited in claim 1, wherein an
20 upper electrode constituted with a metal layer, a silicon layer or a metal layer/silicon layer is formed on an upper area of the crystallized Al₂O₃ film.

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